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High school students' spatial ability and creativity in geometry

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Abstract

The focus of this study is to investigate low and high spatial ability students' potential creativity in geometry. Students were member of Anatolian and State High Schools, in Marmara region of Turkey. Purdue spatial ability, a likert scale instrument (PİSA, 2003) and geometry problem set have been used to collect the data. Findings showed that students in state schools have low spatial ability levels than the Anatolian Students. Furthermore, Anatolian students and State School creativity levels were not different with easy geometry problems.

Keywords: spatial ability; creativity;geometry; high school

1. Introduction

Spatial ability is important factor for mathematics achievement especially for geometry success. (Battitsta, 1990; Battista and Clements, 1996;1991, Battista, Wheatley and Talsma, 1982) . Spatial ability is also important for chemisty (Pribly and Bodner, 1987), physics(Pallrand, and Sbeer, 1984).There are many definitions of spatial ability, but it is generally accepted to be related to skills involving the rotations, retention and transformation of visual information in a spatial context. Visual imagery (Presmeg, 2006) and spatial visualization (Jakubowski and Unal, 2004) plays important role in creativity in mathematics.

Researches have revealed that spatial ability in mathematics provides some advantages for students' learning such as increasing their perception ability, creating different contexts, and generalizing concepts since 1940s. The scientific research has been insufficient in Turkey although the research in this area has started in the world in 1940s sluggishly but accelerated in 1990s. The lack of research on spatial ability creates some gaps and deficiencies in the literature in the country. This research was proposed to present these deficiencies, improve students' spatial ability with new researches and changes in curriculum, and develop some activities to the gaps. The main focus of this study is to examine the students' perceptions against geometry and mathematics questions according to their levels of spatial abilities.

2. Study

This research was conducted among 145 grade 10, 11, and 12 students during their mathematics and geometry courses in a high school and the application of research had three stages. The research took place in two public high

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schools and two Anatolian high schools. 50 Biga Ataturk Anatolian High School (BAAL), 49 Biga Anatolian High School (BAL), 23, Mehmet Akif Ersoy High School (MAEL), and 23 New Biga High School (YBL) have participated in this research.

The first part of the study consists of three geometry questions in a range from easy to difficult. Students were given three different time period to answer each question which are easy, too easy, and difficult. Students were supposed to solve "too easy" question in 5, "easy" question in 7, and "difficult" question in 8 minutes and they were supposed to produce different ways for the solutions of each questions as much as they can. Each question in this application is arranged in a way that students can imagine different ways of solutions in their mind while solving the questions.

The geometry questions

Find the angle "x" in the figure below. Please note that try find the answer as many different ways as you can.

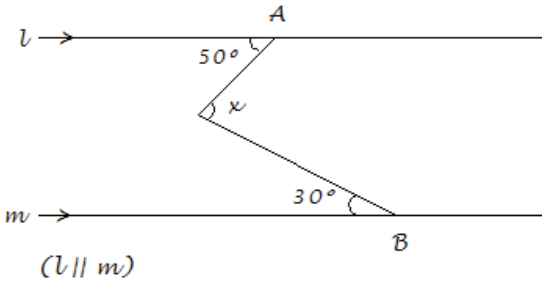

Figure-1: Question 1

Second question WXYZ is a square. M is the middle point of WZ. Find the area of ratio of regions P:Q:R:S. Please try to solve the problem by using different methods.

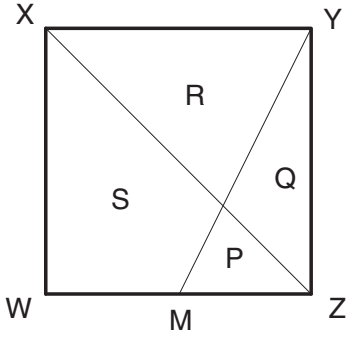

Figure-2: Question 2

In the second stage of the study, a survey with 6 questions was applied. This survey proposed to examine their views of mathematics and mathematics questions, and the different paths that they used to solve the questions. The students were asked to respond questions by selecting the following appropriate options: 1: Strongly Agree, 2: Agree, 3: Disagree: 4: Strongly Disagree.

In the last stage of the study, a test consists of 20 questions were applied to students in order to measure the level of students' spatial ability. The time range for this test was 20 minutes. This test was designed to see how well students can visualize the rotation of three dimensional objects. There are sample questions in the first two pages of the test. There is an object above each question and the same object in the same shape rotated to a different way is located right behind the object. In each question, first, the students were supposed to understand how the object in

the top is rotated. Then, the students should draw a picture in their mind about how the object in the second line would look like when it is rotated in the same manner as it was in the top line. Finally, students were asked to choose one of the objects given in the third line which looks like the rotated version of the object in the second line in correct position based on the pattern in the first line. Each question was mutually exclusive and had 5 choices.

Statistics

Table 1: The mean of number of different solution methods to geometry questions based on Spatial Ability

		Geometry Question_1		Geometry Question_2	
	N	Mean	SD	Mean	SD
Lower ability	54	3.0*	1.1	0.4	0.6
Higher ability	91	3.4*	1.1	0.5	0.6

*p<0.05

Students whom spatial ability scores higher than 11 coded as high spatial ability students whereas students spatial ability scores equal to or lower than 11 coded low spatial ability students. The high ability students were able to find more different methods than the lower group.

Table 2: One-way ANOVA on mathematics test score, geometry scores, algebra scores, statistics and probability scores and arithmetic.

	Sum of Squares	df	Mean Square	F
Between	414.3	3	138.1	11,6*
Within	1675.8	141	11.8	
Total	2090.2	144		

*p<0.05

There is a significant differences among the school based on the spatial ability of students. (F=11,6; df=3, 144; p=0.0). Students in BAAL have higher spatial ability than the other school students. As a result students in BAAL have found more methods to question 1 compare to other school students.

3. Results

The results of this study show that spatial ability (three-dimensional thinking) improves students' understanding of symbols, shapes, tables, and figures. Besides, it assists students in comprehending drawings easily, commenting the visualized information, creating contexts among different concepts easily, generalizing complex concepts, and thinking in different ways. Accordingly, spatial ability plays crucial role to be successful in mathematics, specifically in geometry, for the reason that the field is based on visualization.

The study indicated that the level of students in public high schools is lower than other high schools in terms of geometry achievement. The primary purpose of this study was to show how spatial ability leads students to think in different ways in geometry courses. However, the literature indicates that students have to have basic mathematic skills in order to solve questions even though the questions are presented in different views. The failure of the public high schools students on geometry questions relies on lack of basic geometry knowledge or their incorrect information on basic concepts. In addition, most students in all public high schools attempted to solve questions with some rules by imitating the methods which they used before in a routine way that they were familiar. The reason for this situation is that students have attempted to solve questions in the same ways or they tried to adapt the same incorrect solving methods to the questions. For the first geometry question, some of the students in each high schools provided creative responds for the questions. The literature indicates that the spatial ability can be developed

with certain activities. If the students' who provided different ways of solutions in the first question had sufficient geometry knowledge, they would have found more alternative solutions for the other questions.

On the other hand, it is observed that some of the students could not be successful in the areas in which students required to use only basic brain and visual skills but geometry knowledge. At this point, it can be clearly understood that the role of spatial ability is very important in geometry.

According the Wheatley and Brown, the reason for the students' unwillingness to use spatial ability can be explained by poor conditions of learning environments and obstacles to develop their skills (Wheatley, 1990; Wheatley and Brown, 1994). Besides, Dreyfus (1995) indicates that the source for this unwillingness comes from the lack of using visual materials in teaching mathematics in class (Dreyfus, 1991, PME-15). In other words, it is important that teachers focus on visual materials by using different teaching strategies and material with effective body language and the use of using these kinds of visualized materials will help to develop students' spatial ability. Accordingly, students in BAAL significantly received higher scores than other high schools in spatial ability test since BAAL used visual tools during the mathematics course such as computer, projector, and video.

Finally, this research suggests that the importance of spatial ability in education should be realized by the authorities and this point should be very important issue on educator's agenda. Further, more scientific researches on the use and development of spatial ability should be conducted and relevant resources for the research should be allocated. This study took place in a small town in four high schools in Canakkale. However, the policy implications of this study will be a guideline for the further research in this area.

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